Space Weather Technical Forecast

Issued on Saturday, 13 May 2023 at 13:28 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

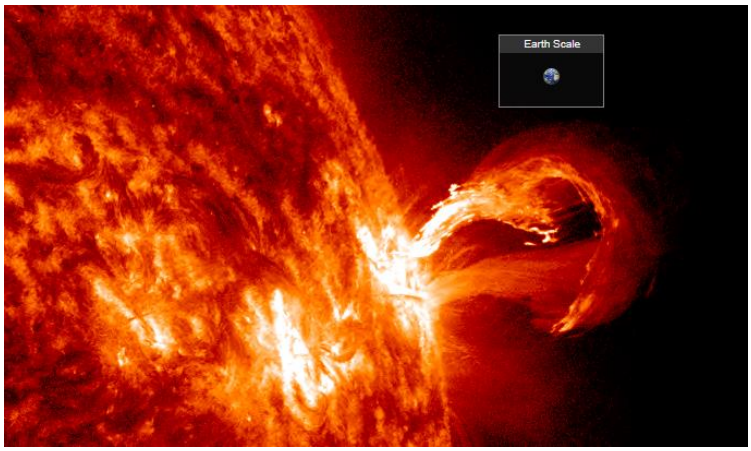
Space Weather Forecast Headline: Slight Chance of further G1 over UTC weekend. Chance of R1/R2 radio blackouts decreasing slightly into new week.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low over the last 24 hours despite the eruption of a C9 long duration flare at 13/0044UTC, originating from AR3296. There are currently up to nine sunspot regions on the visible disc, one of which is a new unnumbered bipolar group developing in the southwest. Most regions are in apparent areal decay and not evolving much in terms of magnetic structure. A few spots were observed developing within AR3304 and AR3305 but this happened at the detriment of others which faded almost simultaneously. AR3296 is now too near the limb to fully discern. AR3302 may contain a mount Wilson delta spot in its trailing group and will need to be monitored.

An explosive CME was observed off the western limb at around 13/0012UTC, following the C9 flare that originated from AR3296 at 12/2345UTC. Its analysis revealed that it is not Earth-directed. There were other CMEs observed in imagery, including from behind the north-eastern limb, which may herald the arrival of a new active region, while a partial halo heading south and west later in the UTC afternoon was determined to be far-sided.

Figure 1: SDO AIA 304 satellite image from 12/2350UTC showing a rather elegant yet impressive ejection of plasma (CME) off the western limb. Courtesy of IAS Helioviewer.



Solar Wind / Geomagnetic Activity: The solar wind, as measured by DSCOVR at L1, was suggestive of the tail-end of a magnetic cloud. The solar wind speed was relatively stable initially, around 550-580km/s, but declined progressively during the second part of the period, down to 440km/s. The solar wind density was above average initially, with a peak of 25ppcc, but declined erratically into the UTC evening and then more gradually into the UTC night and

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morning. The IMF was similarly Moderate and behaving rather chaotically at first but became smoother and weaker over time, with its north-south component remaining largely weak whilst displaying a fairly strong co-aligned bias with Earth's magnetic field. The phi angle started the period orientated largely towards the sun (negative) but transitioned to be mainly away (positive) through the UTC night.

The net result of the above solar wind measures was a mostly Quiet geomagnetic activity although one Minor Geomagnetic Storm G1 interval (Kp 5) occurred between 12/1200-1500UTC, coinciding with an anti-aligned Bz component while the solar wind speed and density were still enhanced.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as measured at GOES16, remained at Background level through the period.
High energy electron flux (greater than 2MeV), as measured at GOES16, declined from Moderate to Background levels, with a peak of 592pfu seen at 12/1250UTC. The 24-hour integrated fluence has been well below Active levels, with a near-level tendency. At 13/0001UTC, 1.19e7 integrated pfu was recorded.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity carries a Chance of returning to Moderate, with this risk greatest over the current UTC weekend while AR3296 remains on the disc, else tentatively falling a little into the new working week, with no major returning regions expected.

Solar Wind / Geomagnetic Activity: The 09 May full halo CME that arrived at Earth yesterday (12 May) has now largely passed, with the solar wind speed in decline. A further CME was observed following the M2.1 flare that occurred on 11 May in the southwest quadrant. It may glance the Earth on 14 into 15 May, but with very low confidence. Finally, the explosive CME that has recently been observed (originating from AR3296) has been analysed and is not considered to contain any Earth-directed component.

With little on the disc coronal hole-wise, geomagnetic activity should remain predominantly Quiet. However the slight chance of a G1 (minor) storm interval cannot be completely ruled out given the existence of the CMEs previously mentioned, at least during the next three days.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux now carries a daily Slight Chance of S1, decreasing slightly into the new working week as the main sunspot responsible for this risk crosses the limb and rotates away.

High energy (greater than 2MeV) electron flux is expected to persist at Normal Background to Moderate levels. The associated 24-hour fluence is forecast to persist below the Active threshold.

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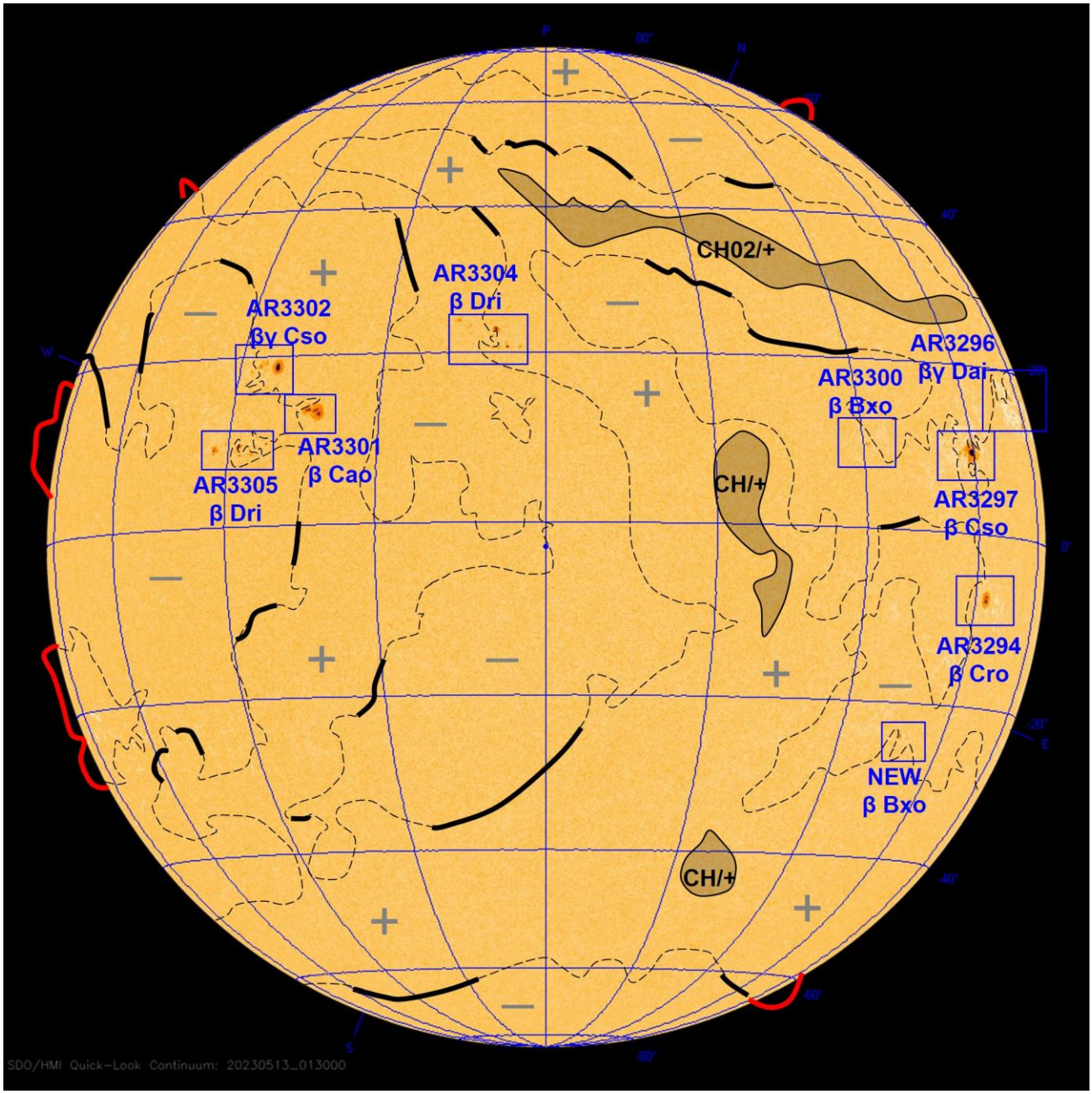
Figure 2. Solar Analysis Valid 13/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:
The full halo CME which left the Sun late on 09 May passed L1 at 12/0549UTC and subsequently registered at Earth on BGS magnetometers with a 20nT deflection in Hartland's H-component at 12/0634UTC. The CME came in largely co-aligned with Earth's magnetic field to limit its effects, and failed to evolve fully into a magnetic-cloud like signature with time, perhaps implying Earth was only affected by the sheath. A G1 interval was observed in the 12-15UTC interval however during a relatively brief negative Bz period, implying that the event was capable of significant activity, even if it fortunately arrived in a favourable orientation. The passing of this event has greatly reduced the likelihood of further geomagnetic activity in the four-day period.

A further CME was observed following the M2.1 flare that occurred on 11 May in the southwestern quadrant. The latest MOSWOC Enlil model has its deterministic run as a near miss, passing 1AU around the turn of the UTC day of 14 into 15 May. Some of the MOSWOC Enlil ensemble members do however show a weak glance late on 14 May, which may perhaps continue into the 15 May, but with very low confidence.

Finally an explosive CME was observed off the western limb at around 13/0012UTC, following the C9 flare that originated from AR3296 at 12/2345UTC. Its analysis revealed that it is not Earth-directed however it is expected to pass closely in front of Earth's pathway and may contribute to keeping solar winds elevated.

The persistence forecast is expected to show little impact from high latitude coronal hole 02, with two unnumbered features near the solar equator and in the southwestern quadrant offering an uncertain but likely limited contribution to any fast wind in the period, with increasingly Quiet conditions otherwise now expected.

All considered, the drivers of the geomagnetic forecast are likely to be weak transients rather than coronal holes during this period, with a residual Slight Chance of G1 from the tail of the 09 May CME, followed by a further Slight Chance of G1 from the 11 May CME, partitioned between the UTC days of 14 and 15 May. The geomagnetic forecast should otherwise become increasingly Quiet.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	10	10	10	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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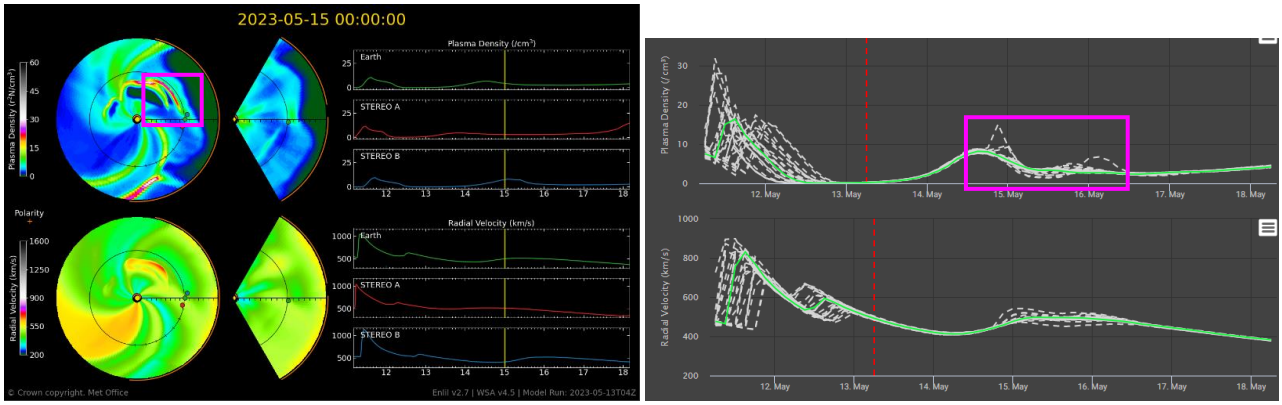
Figure 3: Latest MOSWOC Enlil run and ensemble, showing boxed magenta the 11 May CME with some minor glances in the ensemble but a deterministic miss.



Radio Blackouts - X-Ray Flares:

There are now up to nine sunspot regions on the disc, one of which is a new unnumbered bipolar group developing in the southwest. The most significant region remains AR3296, it is now too near the western limb to fully discern but the assumption is that it managed to maintain a similar magnetic complexity and may still be able to produce M-class flares, even if this region is about to cross the limb and rotate away to the far side.

Most regions are in apparent areal decay and not evolving much in terms of magnetic structure. A few spots were observed developing within AR3304 and AR3305 but this happened at the detriment of others which faded almost simultaneously. AR3302 may contain a mount Wilson delta spot in its trailing group and will need to be monitored. Overall, the Sun seems to be entering a episodic lull in activity, with the Penticton 10.7cm flux falling from a midweek high of 180sfu on 09 May to reach 149sfu on 12 May.

There appears to be little expected in terms of returning Carringtons for sunspot regions in the period, however a northeastern limb CME in the past 24 hours may hint at a region here, although it is at least a day away from the front side judging by its apparent absence from the latest available STEREO A EUVI 195 imagery.

The outlook for X-ray activity is therefore tentatively a slight step-wise decrease as AR3296 departs early on day two, Sunday 14 May, however given the sheer number of sunspot groups, confidence in this assertion is low, and a resurgence in activity could occur at any time.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	40	40	30	30
Very Active	R3 to R5 X Class	No	5	5	5	5

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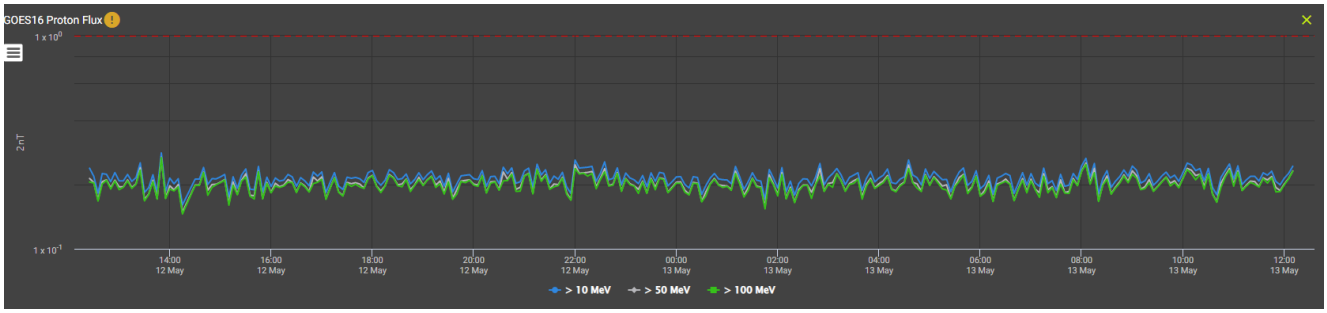
Solar Radiation Storms - (High Energy Protons):
The high energy (greater than 10MeV) proton flux, as observed by GOES16 soon settled to its resting Background into the start of this 24-hour period, and is now therefore comfortably below the S1/Minor Storm threshold.

The most likely source for generating S1 events is now nearing the most reliably-connecting sector of the Sun (with Earth), should a suitable flare and solar radiation storm arise. The probabilities of S1 events are therefore held slightly above the raw risk for the disc, especially given AR3296 is now difficult to fully analyse given limb foreshortening effects. The risk should very gradually ease into the new UTC working week as this spot rotates from this potent position.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	20	20	15	15
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES16 Proton Flux



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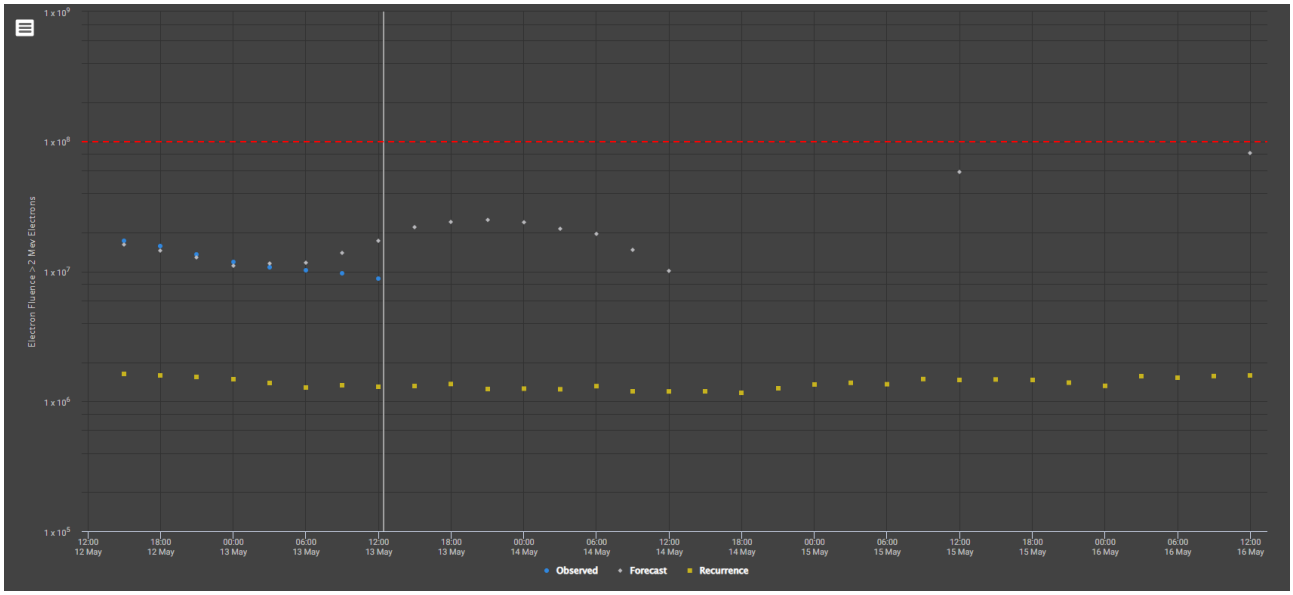
High Energy Electrons Event (≥ 2MeV):
The high energy electron flux (greater than 2MeV) declined from Moderate to Background levels over the past 24 hours. With no very little on the disc likely to cause a significant solar wind speed enhancement, electron flux and fluence ought to remain below Active throughout, with increasing uncertainty later in the period due to the tenuous appearance of (unnumbered) possibly geoeffective coronal holes near the solar equator and in the southwestern quadrant.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	5	10	20
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 5: Latest REFM output, considered to over-estimate the electron counts



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